

WHAT IS CLAIMED IS:

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1. An image decoding device for decoding a hierarchically encoded compressed code obtained by dividing an image into a plurality of tiles and performing discrete wavelet transform on pixel values of the image tile by tile, the image decoding device comprising:

a tile boundary smoothing part that performs smoothing of tile boundary distortion on the image after the decoding by application of a low-pass filter, the tile boundary smoothing part controlling a degree of smoothing of the low-pass filter according to a ratio of decoding quantity to the entire quantity of the compressed code, the decoding quantity being a portion of the compressed code which portion is to be decoded.

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2. The image decoding device as claimed in

claim 1, wherein said tile boundary smoothing part increases the degree of smoothing of the low-pass filter as the ratio of the decoding quantity to the entire quantity of the compressed code decreases.

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3. The image decoding device as claimed in claim 2, wherein a weighting factor  $m$  of a center of the low-pass filter is calculated based on  $m = 32 \cdot R$ , where  $R$  is the ratio of the decoding quantity to the entire quantity of the compressed code.

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4. The image decoding device as claimed in claim 1, wherein said tile boundary smoothing part is prevented from performing the smoothing of tile boundary distortion when the ratio of the decoding quantity to the entire quantity of the compressed code exceeds a predetermined threshold.

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5. The image decoding device as claimed in claim 1, further comprising a tile boundary specifying part that specifies a tile boundary so that said tile boundary smoothing part performs the smoothing of tile boundary distortion only on a peripheral pixel of the specified tile boundary.

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6. The image decoding device as claimed in claim 5, wherein the tile boundary specified by said tile boundary specifying part exists within a region of interest (ROI).

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7. The image decoding device as claimed in claim 1, wherein said tile boundary smoothing part performs the smoothing of tile boundary distortion on the image after the decoding by applying the low-pass filter to peripheral pixels of a tile boundary in the image.

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8. The image decoding device as claimed in claim 1, wherein:

the image is a moving image comprising a plurality of frames successively decodable by the image decoding device; and

said tile boundary smoothing part performs the smoothing of tile boundary distortion on each of the frames after the decoding,

the image decoding device further comprising:

a mode selection part that makes selectable one of a first mode for giving priority to image quality and a second mode for giving priority to processing speed in the smoothing of tile boundary distortion by said tile boundary smoothing part; and

a tile boundary smoothing switching part that switches a processing mode between the first mode and the second mode based on the selection by said mode selection part in the smoothing of tile boundary distortion on the frames after the decoding by said tile boundary smoothing part.

9. The image decoding device as claimed in claim 8, wherein:

said mode selection part makes one of the first and second modes selectable for each of the  
5 frames based on a type of the frame; and

said tile boundary smoothing switching part switches the processing mode to the first mode for a start frame and a final frame of the moving image, and to the second mode for the other frames of the  
10 moving image.

15 10. The image decoding device as claimed in claim 9, wherein said tile boundary smoothing switching part further switches the processing mode to the second mode for a suspended frame of the moving image at suspension of reproduction thereof.

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11. The image decoding device as claimed in  
25 claim 8, wherein:

said mode selection part makes one of the first and second modes selectable for each of the frames based on code quantity of the frame by which code quantity the frame is to be decoded; and

5           said tile boundary smoothing switching part switches the processing mode to the first mode if the code quantity of the frame is less than or equal to a predetermined threshold, and to the second mode if the code quantity of the frame is to be decoded  
10 exceeds the predetermined threshold.

15           12. The image decoding device as claimed in claim 8, wherein:

said mode selection part makes one of the first and second modes selectable based on a frame rate in the smoothing of tile boundary distortion by  
20 said tile boundary smoothing part; and

said tile boundary smoothing switching part switches the processing mode to the first mode if the frame rate is lower than or equal to a predetermined threshold, and to the second mode if the frame rate  
25 exceeds the predetermined threshold.

13. The image decoding device as claimed in  
claim 8, wherein said tile boundary smoothing part  
applies the low-pass filter to peripheral pixels of a  
tile boundary in each of the frames after the  
5 decoding.

10 14. The image decoding device as claimed in  
claim 13, wherein the low-pass filter applied by said  
tile boundary smoothing part is uniform for the  
peripheral pixels in the second mode, and is  
adaptively controlled in the degree of smoothing  
15 according to the peripheral pixels in the first mode.

20 15. The image decoding device as claimed in  
claim 14, wherein said tile boundary smoothing part  
adaptively controls the low-pass filter in the degree  
of smoothing according to a pixel-boundary distance  
and an edge amount of each of the peripheral pixels.

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16. The image decoding device as claimed in  
claim 8, further comprising a tile boundary  
specifying part that specifies a tile boundary so  
that said tile boundary smoothing part performs the  
5 smoothing of tile boundary distortion only on a  
peripheral pixel of the specified tile boundary.

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17. The image decoding device as claimed in  
claim 16, wherein the tile boundary specified by said  
tile boundary specifying part exists within an ROI.

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18. An image processing apparatus,  
comprising:

20 a code stream storing part that stores a  
hierarchically encoded compressed code obtained by  
dividing an image into a plurality of tiles and  
performing discrete wavelet transform on pixel values  
of the image tile by tile;

25 a decoding quantity specifying part that  
specifies decoding quantity of the compressed code,



the decoding quantity being a portion of the  
compressed code which portion is to be decoded;

an image decoding part that decodes the  
compressed code by the decoding quantity specified by  
5 said decoding quantity specifying part; and

an image display part that causes a display  
unit to display the image based on the compressed  
code decoded by said image decoding part,

wherein said image decoding part comprises a  
10 tile boundary smoothing part that performs smoothing  
of tile boundary distortion on the image after the  
decoding by application of a low-pass filter, the  
tile boundary smoothing part controlling a degree of  
smoothing of the low-pass filter according to a ratio  
15 of the decoding quantity to the entire quantity of  
the compressed code.

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19: The image processing apparatus as  
claimed in claim 18, wherein said tile boundary  
smoothing part increases the degree of smoothing of  
the low-pass filter as the ratio of the decoding  
25 quantity to the entire quantity of the compressed

code decreases.

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20. The image processing apparatus as claimed in claim 19, wherein a weighting factor  $m$  of a center of the low-pass filter is calculated based on  $m = 32 \cdot R$ , where  $R$  is the ratio of the decoding  
10 quantity to the entire quantity of the compressed code.

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21. The image processing apparatus as claimed in claim 18, wherein said tile boundary smoothing part is prevented from performing the smoothing of tile boundary distortion when the ratio  
20 of the decoding quantity to the entire quantity of the compressed code exceeds a predetermined threshold.

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22. The image processing apparatus as  
claimed in claim 18, further comprising a tile  
boundary specifying part that specifies a tile  
boundary so that said tile boundary smoothing part  
5 performs the smoothing of tile boundary distortion  
only on a peripheral pixel of the specified tile  
boundary.

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23. The image processing apparatus as  
claimed in claim 22, wherein the tile boundary  
specified by said tile boundary specifying part  
15 exists within a region of interest (ROI).

20 24. The image processing apparatus as  
claimed in claim 18, wherein said tile boundary  
smoothing part performs the smoothing of tile  
boundary distortion on the image after the decoding  
by applying the low-pass filter to peripheral pixels  
25 of a tile boundary in the image.

25. The image processing apparatus as claimed in claim 18, wherein:

the image is a moving image comprising a plurality of frames successively decodable by said  
5 image decoding part;

said tile boundary smoothing part performs the smoothing of tile boundary distortion on each of the frames after the decoding; and

said image decoding part further comprises:  
10 a mode selection part that makes selectable one of a first mode for giving priority to image quality and a second mode for giving priority to processing speed in the smoothing of tile boundary distortion by said tile boundary smoothing part; and  
15 a tile boundary smoothing switching part that switches a processing mode between the first mode and the second mode based on the selection by said mode selection part in the smoothing of tile boundary distortion on the frames after the decoding  
20 by said tile boundary smoothing part.

25 26. The image processing apparatus as

claimed in claim 25, wherein:

said mode selection part makes one of the first and second modes selectable for each of the frames based on a type of the frame; and

5           said tile boundary smoothing switching part switches the processing mode to the first mode for a start frame and a final frame of the moving image, and to the second mode for the other frames of the moving image.

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27. The image processing apparatus as  
15 claimed in claim 26, wherein said tile boundary smoothing switching part further switches the processing mode to the second mode for a suspended frame of the moving image at suspension of reproduction thereof.

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28. The image processing apparatus as  
25 claimed in claim 25, wherein:

said mode selection part makes one of the first and second modes selectable for each of the frames based on code quantity of the frame by which code quantity the frame is to be decoded; and

5           said tile boundary smoothing switching part switches the processing mode to the first mode if the code quantity of the frame is less than or equal to a predetermined threshold, and to the second mode if the code quantity of the frame exceeds the  
10   predetermined threshold.

15           29. The image processing apparatus as claimed in claim 25, wherein:

          said mode selection part makes one of the first and second modes selectable based on a frame rate in the smoothing of tile boundary distortion by  
20   said tile boundary smoothing part; and

          said tile boundary smoothing switching part switches the processing mode to the first mode if the frame rate is lower than or equal to a predetermined threshold, and to the second mode if the frame rate  
25   exceeds the predetermined threshold.

30. The image processing apparatus as  
claimed in claim 25, wherein said tile boundary  
smoothing part applies the low-pass filter to  
peripheral pixels of a tile boundary in each of the  
5 frames after the decoding.

10 31. The image processing apparatus as  
claimed in claim 30, wherein the low-pass filter  
applied by said tile boundary smoothing part is  
uniform for the peripheral pixels in the second mode,  
and is adaptively controlled in the degree of  
15 smoothing according to the peripheral pixels in the  
first mode.

20 32. The image processing apparatus as  
claimed in claim 31, wherein said tile boundary  
smoothing part adaptively controls the low-pass  
filter in the degree of smoothing according to a  
25 pixel-boundary distance and an edge amount of each of

the peripheral pixels.

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33. The image processing apparatus as  
claimed in claim 25, wherein said image decoding part  
further comprises a tile boundary specifying part  
that specifies a tile boundary so that said tile  
10 boundary smoothing part performs the smoothing of  
tile boundary distortion only on a peripheral pixel  
of the specified tile boundary.

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34. The image processing apparatus as  
claimed in claim 33, wherein the tile boundary  
specified by said tile boundary specifying part  
20 exists within an ROI.

25

35. The image processing apparatus as



claimed in claim 18, wherein:

said tile boundary smoothing part applies the low-pass filter to peripheral pixels of a tile boundary; and

5            weighting factors of the low-pass filter are asymmetric with respect a direction of the tile boundary.

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36. The image processing apparatus as claimed in claim 35, wherein a degree of asymmetry of the weighting factors of the low-pass filter depends  
15 on a pixel-boundary distance of one of the peripheral pixels which one is a target of the low-pass filter.

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37. The image processing apparatus as claimed in claim 35, wherein the weighting factors of the low-pass filter are asymmetric in a case where taps of the low-pass filter cross the tile boundary.

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38. The image processing apparatus as  
claimed in claim 35, wherein the weighting factors of  
the low-pass filter are asymmetric in a case where  
mean pixel value error generated in one of the  
5 peripheral pixels which one is a target of the low-  
pass filter is greater than mean pixel value errors  
of two pixels adjacent to the one of the peripheral  
pixels.

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39. The image processing apparatus as  
claimed in claim 35, wherein a degree of asymmetry of  
15 the weighting factors of the low-pass filter differs  
among components of the image.

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40. The image processing apparatus as  
claimed in claim 35, wherein a degree of asymmetry of  
the weighting factors of the low-pass filter differs  
according to a compression rate of the compressed  
25 image.

41. The image processing apparatus as  
claimed in claim 35, wherein a degree of asymmetry of  
the weighting factors of the low-pass filter depends  
on a type of a wavelet filter employed in the  
5 compression and decompression of the image.

10 42. The image processing apparatus as  
claimed in claim 35, wherein a frequency  
characteristic of the low-pass filter depends on a  
pixel-boundary distance of one of the peripheral  
pixels which one is a target of the low-pass filter.

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43. The image processing apparatus as  
20 claimed in claim 42, wherein the frequency  
characteristic of the low-pass filter further depends  
on an edge degree of a periphery of the tile boundary.

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44. The image processing apparatus as claimed in claim 35, wherein a frequency characteristic of the low-pass filter differs among components of the image.

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45. The image processing apparatus as claimed in claim 35, wherein a frequency characteristic of the low-pass filter depends on a compression rate of the compressed image.

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46. The image processing apparatus as claimed in claim 35, wherein a frequency characteristic of the low-pass filter differs according to a type of a wavelet filter employed in the compression and decompression of the image.

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47. The image processing apparatus as claimed in claim 35, wherein a frequency characteristic of the low-pass filter depends on an edge degree of a periphery of the tile boundary.

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48. The image processing apparatus as claimed in claim 35, wherein said tile boundary smoothing part applies the low-pass filter to the peripheral pixels of the tile boundary after inverse color conversion is performed on the decoded image.

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49. The image processing apparatus as claimed in claim 35, wherein said tile boundary smoothing part applies the low-pass filter to the peripheral pixels of the tile boundary before inverse color conversion is performed on the decoded image.

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50. The image processing apparatus as  
claimed in claim 18, wherein:

said tile boundary smoothing part applies  
the low-pass filter to peripheral pixels of a tile  
5 boundary; and

sizes of mean pixel value errors of the  
peripheral pixels are reflected in weighting factors  
of the low-pass filter.

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51. The image processing apparatus as  
claimed in claim 50, wherein a degree of reflection  
15 of the sizes of the mean pixel value errors in the  
weighting factors of the low-pass filter depends on a  
pixel-boundary distance of one of the peripheral  
pixels which one is a target of the low-pass filter.

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52. The image processing apparatus as  
claimed in claim 50, wherein the sizes of the mean  
25 pixel value errors are reflected in the weighting

factors of the low-pass filter in a case where taps  
of the low-pass filter cross the tile boundary.

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53. The image processing apparatus as  
claimed in claim 50, wherein the sizes of the mean  
pixel value errors are reflected in the weighting  
10 factors of the low-pass filter in a case where the  
mean pixel value error generated in one of the  
peripheral pixels which one is a target of the low-  
pass filter is greater than mean pixel value errors  
of two pixels adjacent to the one of the peripheral  
15 pixels.

20 54. The image processing apparatus as  
claimed in claim 50, wherein a degree of reflection  
of the sizes of the mean pixel value errors in the  
weighting factors of the low-pass filter differs  
among components of the image.

25

55. The image processing apparatus as  
claimed in claim 50, wherein a degree of reflection  
of the sizes of the mean pixel value errors in the  
weighting factors of the low-pass filter differs  
5 according to a compression rate of the compressed  
image.

10

56. The image processing apparatus as  
claimed in claim 50, wherein a degree of reflection  
of the sizes of the mean pixel value errors in the  
weighting factors of the low-pass filter depends on a  
15 type of a wavelet filter employed in the compression  
and decompression of the image.

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57. The image processing apparatus as  
claimed in claim 50, wherein a frequency  
characteristic of the low-pass filter depends on a  
pixel-boundary distance of one of the peripheral  
25 pixels which one is a target of the low-pass filter.



58. The image processing apparatus as  
claimed in claim 57, wherein the frequency  
characteristic of the low-pass filter further depends  
on an edge degree of a periphery of the tile boundary.

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59. The image processing apparatus as  
10 claimed in claim 50, wherein a frequency  
characteristic of the low-pass filter differs among  
components of the image.

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60. The image processing apparatus as  
claimed in claim 50, wherein a frequency  
characteristic of the low-pass filter depends on a  
20 compression rate of the compressed image.

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61. The image processing apparatus as

claimed in claim 50, wherein a frequency  
characteristic of the low-pass filter differs  
according to a type of a wavelet filter employed in  
the compression and decompression of the image.

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62. The image processing apparatus as  
10 claimed in claim 50, wherein a frequency  
characteristic of the low-pass filter depends on an  
edge degree of a periphery of the tile boundary.

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63. The image processing apparatus as  
claimed in claim 50, wherein said tile boundary  
smoothing part applies the low-pass filter to the  
20 peripheral pixels of the tile boundary after inverse  
color conversion is performed on the decoded image.

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64. The image processing apparatus as  
claimed in claim 50, wherein said tile boundary  
smoothing part applies the low-pass filter to the  
peripheral pixels of the tile boundary before inverse  
5 color conversion is performed on the decoded image.

10 65. A moving image display system,  
comprising:  
an image input part acquiring a moving image  
composed of a plurality of frames;  
an image compression part that divides each  
15 of the frames into a plurality of tiles and performs  
discrete wavelet transform on pixel values of each of  
the frames tile by tile so as to hierarchically  
compress and encode the moving image;  
an image decoding part that successively  
20 decodes the compressed and encoded frames; and  
an image display part that causes a display  
unit to display the image based on the decoded frames,  
wherein said image decoding part comprises:  
a tile boundary smoothing part that  
25 performs smoothing of tile boundary distortion in

each of the frames after the decoding;

a mode selection part that makes  
selectable one of a first mode for giving priority to  
image quality and a second mode for giving priority  
5 to processing speed in the smoothing of tile boundary  
distortion by said tile boundary smoothing part; and

a tile boundary smoothing switching  
part that switches a processing mode between the  
first mode and the second mode based on the selection  
10 by said mode selection part in the smoothing of tile  
boundary distortion on the frames after the decoding  
by said tile boundary smoothing part.

15

66. The moving image display system as  
claimed in claim 65, wherein:

said mode selection part makes one of the  
20 first and second modes selectable for each of the  
frames based on a type of the frame; and

said tile boundary smoothing switching part  
switches the processing mode to the first mode for a  
start frame and a final frame of the moving image,  
25 and to the second mode for the other frames of the

moving image.

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67. The moving image display system as claimed in claim 66, wherein said tile boundary smoothing switching part further switches the processing mode to the second mode for a suspended  
10 frame of the moving image at suspension of reproduction thereof.

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68. The moving image display system as claimed in claim 65, wherein:

said mode selection part makes one of the first and second modes selectable for each of the  
20 frames based on code quantity of the frame by which code quantity the frame is to be decoded; and

said tile boundary smoothing switching part switches the processing mode to the first mode if the code quantity of the frame is less than or equal to a  
25 predetermined threshold, and to the second mode if

the code quantity of the frame exceeds the predetermined threshold.

5

69. The moving image display system as claimed in claim 65, wherein:

10       said mode selection part makes one of the first and second modes selectable based on a frame rate in the smoothing of tile boundary distortion by said tile boundary smoothing part; and

15       said tile boundary smoothing switching part switches the processing mode to the first mode if the frame rate is lower than or equal to a predetermined threshold and to the second mode if the frame rate exceeds the predetermined threshold.

20

70. The moving image display system as claimed in claim 65, wherein said tile boundary smoothing part applies the low-pass filter to  
25       peripheral pixels of a tile boundary in each of the

frames after the decoding.

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71. The moving image display system as claimed in claim 70, wherein the low-pass filter applied by said tile boundary smoothing part is uniform for the peripheral pixels in the second mode, and is adaptively controlled in the degree of smoothing according to the peripheral pixels in the first mode.

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72. The moving image display system as claimed in claim 71, wherein said tile boundary smoothing part adaptively controls the low-pass filter in the degree of smoothing according to a pixel-boundary distance and an edge amount of each of the peripheral pixels.

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73. The moving image display system as  
claimed in claim 65, wherein said image decoding part  
further comprises a tile boundary specifying part  
that specifies a tile boundary so that said tile  
5 boundary smoothing part performs the smoothing of  
tile boundary distortion only on a peripheral pixel  
of the specified tile boundary.

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74. The moving image display system as  
claimed in claim 73, wherein the tile boundary  
specified by said tile boundary specifying part  
15 exists within an ROI.

20 75. A method of decoding a hierarchically  
encoded compressed code obtained by dividing an image  
into a plurality of tiles and performing discrete  
wavelet transform on pixel values of the image tile  
by tile, the method comprising the step of:

25 (a) performing smoothing of tile boundary



distortion on the image after the decoding by  
application of a low-pass filter,

wherein said step (a) controls a degree of  
smoothing of the low-pass filter according to a ratio  
5 of decoding quantity to the entire quantity of the  
compressed code, the decoding quantity being a  
portion of the compressed code which portion is to be  
decoded.

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76. The method as claimed in claim 75,  
wherein said step (a) increases the degree of  
15 smoothing of the low-pass filter as the ratio of the  
decoding quantity to the entire quantity of the  
compressed code decreases.

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77. The method as claimed in claim 76,  
wherein a weighting factor  $m$  of a center of the low-  
pass filter is calculated based on  $m = 32 \cdot R$ , where  $R$   
25 is the ratio of the decoding quantity to the entire

quantity of the compressed code.

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78. The method as claimed in claim 75,  
wherein said step (a) is prevented from performing  
the smoothing of tile boundary distortion when the  
ratio of the decoding quantity to the entire quantity  
10 of the compressed code exceeds a predetermined  
threshold.

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79. The method as claimed in claim 75,  
further comprising the step of (b) specifying a tile  
boundary so that said step (a) performs the smoothing  
of tile boundary distortion only on a peripheral  
20 pixel of the specified tile boundary.

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80. The method as claimed in claim 79,

wherein the tile boundary specified by said step (b) exists within a region of interest (ROI).

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81. The method as claimed in claim 75,  
wherein said step (a) performs the smoothing of tile  
boundary distortion on the image after the decoding  
10 by applying the low-pass filter to peripheral pixels  
of a tile boundary in the image.

15

82. The method as claimed in claim 75,  
wherein the image is a moving image comprising a  
plurality of frames successively decodable by the  
method, and said step (a) performs the smoothing of  
20 tile boundary distortion on each of the frames after  
the decoding,

the method further comprising the step of  
(b) making selectable one of a first mode for giving  
priority to image quality and a second mode for  
25 giving priority to processing speed in the smoothing

of tile boundary distortion by said step (a) so that  
a processing mode is switched between the first mode  
and the second mode based on the selection by said  
step (b) in the smoothing of tile boundary distortion  
5 on the frames after the decoding by said step (a).

10                   83. The method as claimed in claim 82,  
wherein:  
                    said step (b) makes one of the first and  
second modes selectable for each of the frames based  
on a type of the frame; and  
15                   the processing mode is switched to the first  
mode for a start frame and a final frame of the  
moving image, and to the second mode for the other  
frames of the moving image.

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                    84. The method as claimed in claim 83,  
wherein the processing mode is also switched to the  
25 second mode for a suspended frame of the moving image

at suspension of reproduction thereof.

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85. The method as claimed in claim 82,  
wherein:

said step (b) makes one of the first and  
second modes selectable for each of the frames based  
10 on code quantity of the frame by which code quantity  
the frame is to be decoded; and

the processing mode is switched to the first  
mode if the code quantity of the frame is less than  
or equal to a predetermined threshold, and to the  
15 second mode if the code quantity of the frame exceeds  
the predetermined threshold.

20

86. The method as claimed in claim 82,  
wherein:

said step (b) makes one of the first and  
second modes selectable based on a frame rate in the  
25 smoothing of tile boundary distortion by said step

(a); and

the processing mode is switched to the first mode if the frame rate is lower than or equal to a predetermined threshold, and to the second mode if  
5 the frame rate exceeds the predetermined threshold.

10 87. The method as claimed in claim 82, wherein said step (a) applies the low-pass filter to peripheral pixels of a tile boundary in each of the frames after the decoding.

15

88. The method as claimed in claim 87, wherein the low-pass filter applied by said step (a)  
20 is uniform for the peripheral pixels in the second mode, and is adaptively controlled in the degree of smoothing according to the peripheral pixels in the first mode.

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89. The method as claimed in claim 88,  
wherein said step (a) adaptively controls the low-  
pass filter in the degree of smoothing according to a  
pixel-boundary distance and an edge amount of each of  
5 the peripheral pixels.

10 90. The method as claimed in claim 82,  
further comprising the step of (c) specifying a tile  
boundary so that said step (b) performs the smoothing  
of tile boundary distortion only on a peripheral  
pixel of the specified tile boundary.

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91. The method as claimed in claim 90,  
20 wherein the tile boundary specified by said step (c)  
exists within an ROI.

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92. The method as claimed in claim 75,  
wherein:

said step (a) applies the low-pass filter to  
peripheral pixels of a tile boundary; and

5            weighting factors of the low-pass filter are  
asymmetric with respect a direction of the tile  
boundary.

10

93. The method as claimed in claim 92,  
wherein a degree of asymmetry of the weighting  
factors of the low-pass filter depends on a pixel-  
15    boundary distance of one of the peripheral pixels  
which one is a target of the low-pass filter.

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94. The method as claimed in claim 92,  
wherein the weighting factors of the low-pass filter  
are asymmetric in a case where taps of the low-pass  
filter cross the tile boundary.

25



95. The method as claimed in claim 92,  
wherein the weighting factors of the low-pass filter  
are asymmetric in a case where mean pixel value error  
generated in one of the peripheral pixels which one  
5 is a target of the low-pass filter is greater than  
mean pixel value errors of two pixels adjacent to the  
one of the peripheral pixels.

10

96. The method as claimed in claim 92,  
wherein a degree of asymmetry of the weighting  
factors of the low-pass filter differs among  
15 components of the image.

20 97. The method as claimed in claim 92,  
wherein a degree of asymmetry of the weighting  
factors of the low-pass filter differs according to a  
compression rate of the compressed image.

25

98. The method as claimed in claim 92,  
wherein a degree of asymmetry of the weighting  
factors of the low-pass filter depends on a type of a  
wavelet filter employed in the compression and  
5 decompression of the image.

10 99. The method as claimed in claim 92,  
wherein a frequency characteristic of the low-pass  
filter depends on a pixel-boundary distance of one of  
the peripheral pixels which one is a target of the  
low-pass filter.

15

100. The method as claimed in claim 99,  
20 wherein the frequency characteristic of the low-pass  
filter further depends on an edge degree of a  
periphery of the tile boundary.

25

101. The method as claimed in claim 92,  
wherein a frequency characteristic of the low-pass  
filter differs among components of the image.

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102. The method as claimed in claim 92,  
wherein a frequency characteristic of the low-pass  
10 filter depends on a compression rate of the  
compressed image.

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103. The method as claimed in claim 92,  
wherein a frequency characteristic of the low-pass  
filter differs according to a type of a wavelet  
filter employed in the compression and decompression  
20 of the image.

25

104. The method as claimed in claim 92,

wherein a frequency characteristic of the low-pass filter depends on an edge degree of a periphery of the tile boundary.

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105. The method as claimed in claim 92, wherein said step (a) applies the low-pass filter to  
10 the peripheral pixels of the tile boundary after inverse color conversion is performed on the decoded image.

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106. The method as claimed in claim 92, wherein said step (a) applies the low-pass filter to the peripheral pixels of the tile boundary before  
20 inverse color conversion is performed on the decoded image.

25

107. The method as claimed in claim 75,  
wherein:

said step (a) applies the low-pass filter to  
peripheral pixels of a tile boundary; and

5 sizes of mean pixel value errors of the  
peripheral pixels are reflected in weighting factors  
of the low-pass filter.

10

108. The method as claimed in claim 107,  
wherein a degree of reflection of the sizes of the  
mean pixel value errors in the weighting factors of  
15 the low-pass filter depends on a pixel-boundary  
distance of one of the peripheral pixels which one is  
a target of the low-pass filter.

20

109. The method as claimed in claim 107,  
wherein the sizes of the mean pixel value errors are  
reflected in the weighting factors of the low-pass  
25 filter in a case where taps of the low-pass filter

cross the tile boundary.

5

110. The method as claimed in claim 107,  
wherein the sizes of the mean pixel value errors are  
reflected in the weighting factors of the low-pass  
filter in a case where the mean pixel value error  
10 generated in one of the peripheral pixels which one  
is a target of the low-pass filter is greater than  
mean pixel value errors of two pixels adjacent to the  
one of the peripheral pixels.

15

111. The method as claimed in claim 107,  
wherein a degree of reflection of the sizes of the  
20 mean pixel value errors in the weighting factors of  
the low-pass filter differs among components of the  
image.

25

112. The method as claimed in claim 107,  
wherein a degree of reflection of the sizes of the  
mean pixel value errors in the weighting factors of  
the low-pass filter differs according to a  
5 compression rate of the compressed image.

10 113. The method as claimed in claim 107,  
wherein a degree of reflection of the sizes of the  
mean pixel value errors in the weighting factors of  
the low-pass filter depends on a type of a wavelet  
filter employed in the compression and decompression  
15 of the image.

20 114. The method as claimed in claim 107,  
wherein a frequency characteristic of the low-pass  
filter depends on a pixel-boundary distance of one of  
the peripheral pixels which one is a target of the  
low-pass filter.

25

115. The method as claimed in claim 114,  
wherein the frequency characteristic of the low-pass  
filter further depends on an edge degree of a  
periphery of the tile boundary.

5

116. The method as claimed in claim 107,  
10 wherein a frequency characteristic of the low-pass  
filter differs among components of the image.

15

117. The method as claimed in claim 107,  
wherein a frequency characteristic of the low-pass  
filter depends on a compression rate of the  
compressed image.

20

118. The method as claimed in claim 107,  
25 wherein a frequency characteristic of the low-pass



filter differs according to a type of a wavelet  
filter employed in the compression and decompression  
of the image.

5

119. The method as claimed in claim 107,  
wherein a frequency characteristic of the low-pass  
10 filter depends on an edge degree of a periphery of  
the tile boundary.

15

120. The method as claimed in claim 107,  
wherein said step (a) applies the low-pass filter to  
the peripheral pixels of the tile boundary after  
inverse color conversion is performed on the decoded  
20 image.

25

121. The method as claimed in claim 107,

wherein said step (a) applies the low-pass filter to the peripheral pixels of the tile boundary before inverse color conversion is performed on the decoded image.

5

122. A computer-readable recording medium  
10 storing a program for causing a computer to execute a method of decoding a hierarchically encoded compressed code obtained by dividing an image into a plurality of tiles and performing discrete wavelet transform on pixel values of the image tile by tile,  
15 the method comprising the step of:

(a) performing smoothing of tile boundary distortion on the image after the decoding by application of a low-pass filter,

wherein said step (a) controls a degree of  
20 smoothing of the low-pass filter according to a ratio of decoding quantity to the entire quantity of the compressed code, the decoding quantity being a portion of the compressed code which portion is to be decoded.

25

123. The computer-readable recording medium  
as claimed in claim 122, wherein said step (a)  
increases the degree of smoothing of the low-pass  
filter as the ratio of the decoding quantity to the  
5 entire quantity of the compressed code decreases.

10 124. The computer-readable recording medium  
as claimed in claim 123, wherein a weighting factor  $m$   
of a center of the low-pass filter is calculated  
based on  $m = 32 \cdot R$ , where  $R$  is the ratio of the  
decoding quantity to the entire quantity of the  
15 compressed code.

20 125. The computer-readable recording medium  
as claimed in claim 122, wherein said step (a) is  
prevented from performing the smoothing of tile  
boundary distortion when the ratio of the decoding  
quantity to the entire quantity of the compressed  
25 code exceeds a predetermined threshold.

126. The computer-readable recording medium  
as claimed in claim 122, wherein the method further  
comprises the step of (b) specifying a tile boundary  
so that said step (a) performs the smoothing of tile  
5 boundary distortion only on a peripheral pixel of the  
specified tile boundary.

10

127. The computer-readable recording medium  
as claimed in claim 126, wherein the tile boundary  
specified by said step (b) exists within a region of  
interest (ROI).

15

128. The computer-readable recording medium  
20 as claimed in claim 122, wherein said step (a)  
performs the smoothing of tile boundary distortion on  
the image after the decoding by applying the low-pass  
filter to peripheral pixels of a tile boundary in the  
image.

25

129. The computer-readable recording medium  
as claimed in claim 122, wherein the image is a  
moving image comprising a plurality of frames  
successively decodable by the method, and said step  
5 (a) performs the smoothing of tile boundary  
distortion on each of the frames after the decoding,  
the method further comprising the step of  
(b) making selectable one of a first mode for giving  
priority to image quality and a second mode for  
10 giving priority to processing speed in the smoothing  
of tile boundary distortion by said step (a) so that  
a processing mode is switched between the first mode  
and the second mode based on the selection by said  
step (b) in the smoothing of tile boundary distortion  
15 on the frames after the decoding by said step (a).

20 130. The computer-readable recording medium  
as claimed in claim 129, wherein:  
said step (b) makes one of the first and  
second modes selectable for each of the frames based  
on a type of the frame; and  
25 the processing mode is switched to the first

mode for a start frame and a final frame of the moving image, and to the second mode for the other frames of the moving image.

5

131. The computer-readable recording medium as claimed in claim 130, wherein the processing mode  
10 is also switched to the second mode for a suspended frame of the moving image at suspension of reproduction thereof.

15

132. The computer-readable recording medium as claimed in claim 129, wherein:

said step (b) makes one of the first and  
20 second modes selectable for each of the frames based on code quantity of the frame by which code quantity the frame is to be decoded; and

the processing mode is switched to the first mode if the code quantity of the frame is less than  
25 or equal to a predetermined threshold, and to the

second mode if the code quantity of the frame exceeds the predetermined threshold.

5

133. The computer-readable recording medium as claimed in claim 129, wherein:

10       said step (b) makes one of the first and second modes selectable based on a frame rate in the smoothing of tile boundary distortion by said step (a); and

          the processing mode is switched to the first mode if the frame rate is lower than or equal to a  
15       predetermined threshold, and to the second mode if the frame rate exceeds the predetermined threshold.

20

134. The computer-readable recording medium as claimed in claim 129, wherein said step (a) applies the low-pass filter to peripheral pixels of a tile boundary in each of the frames after the  
25       decoding.

135. The computer-readable recording medium  
as claimed in claim 134, wherein the low-pass filter  
applied by said step (a) is uniform for the  
peripheral pixels in the second mode, and is  
5 adaptively controlled in the degree of smoothing  
according to the peripheral pixels in the first mode.

10

136. The computer-readable recording medium  
as claimed in claim 135, wherein said step (a)  
adaptively controls the low-pass filter in the degree  
of smoothing according to a pixel-boundary distance  
15 and an edge amount of each of the peripheral pixels.

20

137. The computer-readable recording medium  
as claimed in claim 129, wherein the method further  
comprises the step of (c) specifying a tile boundary  
so that said step (b) performs the smoothing of tile  
boundary distortion only on a peripheral pixel of the  
25 specified tile boundary.



138. The computer-readable recording medium as claimed in claim 137, wherein the tile boundary specified by said step (c) exists within an ROI.

5

139. The computer-readable recording medium as claimed in claim 122, wherein:

10           said step (a) applies the low-pass filter to peripheral pixels of a tile boundary; and

          weighting factors of the low-pass filter are asymmetric with respect a direction of the tile boundary.

15

140. The computer-readable recording medium as claimed in claim 139, wherein a degree of asymmetry of the weighting factors of the low-pass filter depends on a pixel-boundary distance of one of the peripheral pixels which one is a target of the low-pass filter.

25

141. The computer-readable recording medium  
as claimed in claim 139, wherein the weighting  
factors of the low-pass filter are asymmetric in a  
case where taps of the low-pass filter cross the tile  
5 boundary.

10 142. The computer-readable recording medium  
as claimed in claim 139, wherein the weighting  
factors of the low-pass filter are asymmetric in a  
case where mean pixel value error generated in one of  
the peripheral pixels which one is a target of the  
15 low-pass filter is greater than mean pixel value  
errors of two pixels adjacent to the one of the  
peripheral pixels.

20

143. The computer-readable recording medium  
as claimed in claim 139, wherein a degree of  
asymmetry of the weighting factors of the low-pass  
25 filter differs among components of the image.

144. The computer-readable recording medium  
as claimed in claim 139, wherein a degree of  
asymmetry of the weighting factors of the low-pass  
filter differs according to a compression rate of the  
5 compressed image.

10 145. The computer-readable recording medium  
as claimed in claim 139, wherein a degree of  
asymmetry of the weighting factors of the low-pass  
filter depends on a type of a wavelet filter employed  
in the compression and decompression of the image.

15

146. The computer-readable recording medium  
20 as claimed in claim 139, wherein a frequency  
characteristic of the low-pass filter depends on a  
pixel-boundary distance of one of the peripheral  
pixels which one is a target of the low-pass filter.

25

147. The computer-readable recording medium  
as claimed in claim 146, wherein the frequency  
characteristic of the low-pass filter further depends  
on an edge degree of a periphery of the tile boundary.

5

148. The computer-readable recording medium  
10 as claimed in claim 139, wherein a frequency  
characteristic of the low-pass filter differs among  
components of the image.

15

149. The computer-readable recording medium  
as claimed in claim 139, wherein a frequency  
characteristic of the low-pass filter depends on a  
20 compression rate of the compressed image.

25

150. The computer-readable recording medium

as claimed in claim 139, wherein a frequency characteristic of the low-pass filter differs according to a type of a wavelet filter employed in the compression and decompression of the image.

5

151. The computer-readable recording medium  
10 as claimed in claim 139, wherein a frequency characteristic of the low-pass filter depends on an edge degree of a periphery of the tile boundary.

15

152. The computer-readable recording medium  
as claimed in claim 139, wherein said step (a)  
applies the low-pass filter to the peripheral pixels  
20 of the tile boundary after inverse color conversion  
is performed on the decoded image.

25

153. The computer-readable recording medium  
as claimed in claim 139, wherein said step (a)  
applies the low-pass filter to the peripheral pixels  
of the tile boundary before inverse color conversion  
5 is performed on the decoded image.

10 154. The computer-readable recording medium  
as claimed in claim 122, wherein:

said step (a) applies the low-pass filter to  
peripheral pixels of a tile boundary; and

sizes of mean pixel value errors of the  
15 peripheral pixels are reflected in weighting factors  
of the low-pass filter.

20

155. The computer-readable recording medium  
as claimed in claim 154, wherein a degree of  
reflection of the sizes of the mean pixel value  
errors in the weighting factors of the low-pass  
25 filter depends on a pixel-boundary distance of one of

the peripheral pixels which one is a target of the  
low-pass filter.

5

156. The computer-readable recording medium  
as claimed in claim 154, wherein the sizes of the  
mean pixel value errors are reflected in the  
10 weighting factors of the low-pass filter in a case  
where taps of the low-pass filter cross the tile  
boundary.

15

157. The computer-readable recording medium  
as claimed in claim 154, wherein the sizes of the  
mean pixel value errors are reflected in the  
20 weighting factors of the low-pass filter in a case  
where the mean pixel value error generated in one of  
the peripheral pixels which one is a target of the  
low-pass filter is greater than mean pixel value  
errors of two pixels adjacent to the one of the  
25 peripheral pixels.

158. The computer-readable recording medium  
as claimed in claim 154, wherein a degree of  
reflection of the sizes of the mean pixel value  
errors in the weighting factors of the low-pass  
5 filter differs among components of the image.

10 159. The computer-readable recording medium  
as claimed in claim 154, wherein a degree of  
reflection of the sizes of the mean pixel value  
errors in the weighting factors of the low-pass  
filter differs according to a compression rate of the  
15 compressed image.

20 160. The computer-readable recording medium  
as claimed in claim 154, wherein a degree of  
reflection of the sizes of the mean pixel value  
errors in the weighting factors of the low-pass  
filter depends on a type of a wavelet filter employed  
25 in the compression and decompression of the image.



161. The computer-readable recording medium  
as claimed in claim 154, wherein a frequency  
characteristic of the low-pass filter depends on a  
pixel-boundary distance of one of the peripheral  
5 pixels which one is a target of the low-pass filter.

10 162. The computer-readable recording medium  
as claimed in claim 161, wherein the frequency  
characteristic of the low-pass filter further depends  
on an edge degree of a periphery of the tile boundary.

15

163. The computer-readable recording medium  
as claimed in claim 154, wherein a frequency  
20 characteristic of the low-pass filter differs among  
components of the image.

25

164. The computer-readable recording medium  
as claimed in claim 154, wherein a frequency  
characteristic of the low-pass filter depends on a  
compression rate of the compressed image.

5

165. The computer-readable recording medium  
10 as claimed in claim 154, wherein a frequency  
characteristic of the low-pass filter differs  
according to a type of a wavelet filter employed in  
the compression and decompression of the image.

15

166. The computer-readable recording medium  
as claimed in claim 154, wherein a frequency  
20 characteristic of the low-pass filter depends on an  
edge degree of a periphery of the tile boundary.

25

167. The computer-readable recording medium  
as claimed in claim 154, wherein said step (a)  
applies the low-pass filter to the peripheral pixels  
of the tile boundary after inverse color conversion  
5 is performed on the decoded image.

10 168. The computer-readable recording medium  
as claimed in claim 154, wherein said step (a)  
applies the low-pass filter to the peripheral pixels  
of the tile boundary before inverse color conversion  
is performed on the decoded image.

15

169. A program for causing a computer to  
20 execute a method of decoding a hierarchically encoded  
compressed code obtained by dividing an image into a  
plurality of tiles and performing discrete wavelet  
transform on pixel values of the image tile by tile,  
the method comprising the step of:

25 (a) performing smoothing of tile boundary

distortion on the image after the decoding by  
application of a low-pass filter,

wherein said step (a) controls a degree of  
smoothing of the low-pass filter according to a ratio  
5 of decoding quantity to the entire quantity of the  
compressed code, the decoding quantity being a  
portion of the compressed code which portion is to be  
decoded.

10

170. The program as claimed in claim 169,  
wherein the image is a moving image comprising a  
15 plurality of frames successively decodable by the  
method, and said step (a) performs the smoothing of  
tile boundary distortion on each of the frames after  
the decoding,

the method further comprising the step of  
20 (b) making selectable one of a first mode for giving  
priority to image quality and a second mode for  
giving priority to processing speed in the smoothing  
of tile boundary distortion by said step (a) so that  
a processing mode is switched between the first mode  
25 and the second mode based on the selection by said

step (b) in the smoothing of tile boundary distortion  
on the frames after the decoding by said step (a).

5

171. The program as claimed in claim 169,  
wherein:

said step (a) applies the low-pass filter to  
10 peripheral pixels of a tile boundary; and  
weighting factors of the low-pass filter are  
asymmetric with respect a direction of the tile  
boundary.

15

172. The program as claimed in claim 169,  
wherein:

20 said step (a) applies the low-pass filter to  
peripheral pixels of a tile boundary; and  
sizes of mean pixel value errors of the  
peripheral pixels are reflected in weighting factors  
of the low-pass filter.